Behavorial Ecology of the Nevada Kit Fox

(Vulpes Macrotis Nevadensis) On a Managed

Desert Rangeland

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BEHAVORIAL ECOLOGY OF THE NEVADA KIT FOX (*VULPES MACROTIS NEVADENSIS*) ON A MANAGED DESERT RANGELAND

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ABSTRACT

A total of 65 kit foxes were ear tagged at the Desert Experimental Range in Western Utah. Thirty-eight, including adults and juvenile foxes at six den sites were radio-collared during the course of the study. Mortality rate was 55%. Most causes were unknown and may have been related to low body condition indices. Predation by coyotes (Canis latrans) was the major known cause of death. Home ranges averaged 2.3 sq. km for males, 1.8 sq. km for females. A negative correlation existed between home range size and body condition indices. Scat analyses of adults and juveniles revealed a strong dependency on black-tailed jackrabbits (Lepus californicus), Ord's kangaroo rats (Dipodomys ordii) and horned larks (Eremophilia alpestris). An expanded social structure was observed as indicated by frequent visitations between foxes from different dens and poor expression of territoriality. Kit foxes did not appear to react to the presence or absence of sheep or cattle. Dispersal for young began by Mid-August with straight-line distances ranging from 24 to 64 km.

INTRODUCTION

The kit fox (*Vulpes macrotis Merriam*) inhabits deserts and semi-arid lands of western North America. Eight subspecies have traditionally been recognized (McGrew, 1972) and one of these, the San Joaquin kit fox (*V. m. mutica Merriam*), is considered endangered. Hall and Kelson (1959) studied five of these subspecies recognizing the San Joaquin kit fox as a distinct subspecies while *V. m. arsupius, deria* and *tenuirostris* were considered synonymous with the subspecies *marsupius*. Hall (1946) also did not consider *nevadensis* as being distinct from *arsipius* suggesting that perhaps there are a total of only four subspecies. A 1 year study (from January until December, 1983) of *V. m. nevadensis* Goldman, the Nevada kit fox, was completed under joint cooperation with Brigham Young University, the U. S. Forest Service and Utah Wildlife Resources at the Desert Experimental Range in Western Utah. The overall objective of this study was to document adaptive habitat selection, reproduction, food habits, dispersal, and other behavioral expressions of kit foxes on a desert rangeland managed for winter grazing for domestic sheep and cattle.

DESCRIPTION OF STUDY AREA

The Desert Experimental Range is a 225 sq. km Federal facility located toward the southeastern edge of the known distribution of *V. m. nevadensis* (Hall and Kelson, 1959; Fig. 1). The topography of this facility is typical of the cold-desert basin. About 75% of the land area of the study area is alluvial or flat valley bottom. Average annual precipitation is 157 mm, much of which falls as snow

during the winter months. Daily maximum and minimum temperatures range from -11 to 4.2 C in January, to 13 to 33 C in July. Elevation of the study area ranged from 1600 to 1700 m.

Dominant shrub species are common winterfat (Ceratoides lanata), bud sagebrush (Artemisia spinescens), black sagebrush (Artemisia nova), shadscale saltbrush (Atriplex confertifolia), and low rabbitbrush (Chrysothamnus viscidiflorus sp.).

Perennial grasses include Indian ricegrass (Oryzopsis hymenoides), galleta grass (Hilaria jamesii), and sand dropseed (Sporobolus cryptandrus). For 50 years, the Desert Experimental Range has been involved continuously in winter grazing studies of domestic sheep and their relationship to desert plant communties. Cattle are also grazed during winter within areas on site.

METHODS AND PROCEDURES

The study area was searched extensively by foot, fixed-wing aircraft and automobile for active den sites. Kit foxes were captured in two different sizes of Tomahawk traps (38 by 107 cm double-door for adults and 26 by 66 cm single-door for pups) baited with pieces of black-tailed jackrabbit (Lepus californicus). Adults were trapped at active dens, inactive dens visited by some foxes, and at sites used as scent posts. Pups were trapped at active dens only.

Each pair of adult foxes, associated with six active dens, were anesthetized (ketamine hydrochloride, 0.3cc/kg dosage), radio-collared, sexed, weighed, measured, marked with ear tags,

checked for external parasites and released. Measurements included total length, length of tail, ear, hind foot, zygomatic breadth, and condylobasal length. Upon emergence from dens, pups were processed on a weekly basis in the same manner as adults, and one male and female from each den were radio-collared later in the summer. In addition, tooth eruption and development were noted. Tooth measurements including distal canine to proximal PM 4 (upper), distal incisors to proximal PM 4 (upper), upper canine length, and distal canine to proximal PM 1 were taken. Approximate whelping dates were determined by comparing tooth eruptions and body weights of pups with those of two pups reared in the laboratory during the study.

Blood samples (obtained from the jugular vein) were taken from 33 of the 42 foxes, and a white cell differential was determined for each sample. Blood samples were obtained from laboratory-reared kit foxes for comparison.

The collar, transmitter, and battery weighed 122-125 g. The cable antenna extended approximately 36 cm from the collar. Each transmitter operated on a different frequency allowing identification of individual foxes. Tracking of radio-collared foxes was accomplished by use of a Telonics TR-2 receiver/scanner using both a truck-mounted and hand-held antenna. Locations were plotted from angles determined by triangulation at varying times during the night. Considerable effort was made to locate instrumented foxes at least every other night to document movement and every day to document use of dens. An average of 110 plots (from triangulation)/adult fox was used in determining home range size. By plotting coordinates onto a

topographical map, approximate locations on any given night were determined for each adult fox. Shape and size of home range were determined for each fox by connecting outermost radio contact points.

Scats were collected from around each of the 6 dens approximately every 2 weeks. Scats were prepared for analysis (Green and Flinders, 1981), and 100 random points were used to locate food items in pooled scats from each den each collection period. Pup scats were collected separately until early July when they could no longer be distinguished from adult scat.

To assess abundance of small mammals, 100 Sherman traps at 10-m intervals were randomly established within known hunting areas of each pair of foxes. Museum specials (kill traps) were not used because of the likelihood for rodents to be removed from traps by foxes. Small mammals were trapped, marked, and released for 5 consecutive nights, from 26 May to 4 June. Additional trapping near Dens 3 and 6 took place between 5-9 September. Density/ha was calculated (Caughley, 1977) using original captures within a 10 by 1000-m belt transect. Leporid abundance was assessed in spring, summer and fall periods by counting number of leporids considered within the 9.2 m (30 ft.)-belt transect along selected sections of dirt roadways on the study site (Flinders and Hansen, 1973). The average of 3 nights of counting was used as an estimate of abundance. Birds were censused late July for 3 consecutive days, in early morning, along the same roadways used to assess leporids. Density/sq. km estimates of birds and hares were calculated from numbers seen/area of transect (Caughley , 1977).

Vegetative characteristics near natal dens were assessed in two ways. The point-centered quarter method (Mueller-Dombois and Ellenberg, 1974) was used to determine height, cover and density of woody plant species at 25 points on a 40x40 m grid centered over each natal den site. Percent cover of grasses and forbs was assessed within 25 plots (20 by 50 cm) located on the same points as above, according to the method outlined by Daubenmire (1959). Soil samples were taken from each natal den site at the surface and 15 cm below the surface to determine soil texture. Similarity indices (Ruzicka, 1958). were computed for relative dominance and average shrub height for natal dens, home range vegetation, relative percent frequency of adult and juvenile diets for each den relative to other dens, similarity between winter-spring and summer-fall adult diets, and between prey availability and relative percent frequency of prey in adult and juvenile diets. Stand cluster analyses (Sneath and Sokal, 1973) were performed from those similarity indices that compared each den or home range relative to other dens or home ranges. All statistical tests including correlation, linear regression, mutilple regression, and chi square were considered significant at 0.05 alpha level.

RESULTS

Kit Fox Trapping Success

During the course of the study, 65 different kit foxes (35 males and 30 females) were ear tagged. Of these, 38 were radio-collared for detailed tracking. The radio collars did not appear to have any adverse effect on kit fox behavior. Data in Table 1 includes the

known information regarding natality and mortality of adult pairs and resultant whelps at each of the six den sites studied.

There was little difficulty in initially trapping adult and young foxes. Most adults, however, avoided traps after the first or second time they were captured and only a few were recaptured during the course of the study. Consequently, there was difficulty in recapturing adults at the end of the study for collar removal. Pups began avoiding the smaller traps in mid-summer and larger adult traps were needed to capture them. By early fall, most pups had died, dispersed, moved to other dens away from their parents, or simply avoided the traps.

Pieces of black-tailed jackrabbit either fresh, putrid or scented with fox lure, was the most successful bait. In late July, water was used with some success for foxes not near permanent water, but rains in August rendered this bait ineffective. Near the end of the study, smoked salmon worked well as bait to recapture some of the more wary foxes for radio collar removal. Live deer mice (Peromyscus maniculatus) were used successfully in recapturing a transient male that could not be retrapped with jackrabbit bait.

Twenty-three known mortalities occurred in the 42 kit fox pairs and whelps at the six den sites. A yearling female helper at Den 1 died along with perhaps all of the foxes at that den. Timimg of mortalities, as well as known causes are identified in Table 1. It is not known whether the possible drowning was actually a drowning. The lungs floated when placed in water (lungs of drowning victims usually

sink because they are water-filled) during an autopsy, and kit foxes are known to swim (Reeder, 1949). The kit fox killed by a golden eagle was apparently a rare incidence. In a study of golden eagle nest contents in western Texas and in New Mexico, only one nest was found to contain kit fox remains (Mollhagen et al., 1972). The apparent kills by coyotes appear to be unique in that such mortalities were not reported by Egoscue (1962) or Morrell (1972), although Seton (1925) observed coyotes attempting to capture kit foxes. There is a possibility such predation on kit foxes in the study area may reflect prey switching on the part of coyotes as a result of a cyclic low in the black-tailed jackrabbit population at the time of the study. A radio-collared juvenile female from Den 5 was found to have a severe elbow injury on her left front leg. Treatment, unfortunately, was not in time since she was found dead 2 days later, apparently unable to successfully hunt in her injured condition. The Den 4 adult male was caught by a trapper just south of the DER headquarters 1 month after the study ended. With the exception of the Den 5 adult male and a Den 6 juvenile female, who were found inside dens, all other mortalities occurred away from dens. Because of the relative isolation and nature of the study area, varmint hunting and road kills apparently are not major mortality factors in the study area. Only one juvenile female fox (whose ear tags were missing) was found shot.

Den Site Characteristics

The overall number of entrances at studied den sites varied from 1 to 25. One or two entrances at each den were apparently used for waste disposal, judging from the large amount of scat deposited outside these entrances. The cleaning out of scat occurred every 1-2 weeks. Some entrances, particularly in older, multi-entrance dens, were in poor condition and apparently not used. Entrances were usually taller than wide. The average diameter of natal den entrances was 23 by 15 cm. Each entrance had a mound of excavated dirt in front and many had a long ramp of excavated dirt extending as far as 3 meters from the entrance. Egoscue (1956) reported dens typically had at least one ramp extending 1.5-2.5 meters from the mouth of the entrance. Most dens had one or two shallow basins on the surface where adults were often seen napping in the daytime. The Den 4 family moved from the natal den when their pups were approximately 2 weeks old to an already established den beneath a group of 4 cedar post piles and shared this site with a family of striped skunks (_Mephitis mephitis_). The post piles were approximately 12 m apart, three of which were connected by fox tunnels. These same foxes later moved into an old den beneath an abandoned building and remained there for approximately 1 month. This was the only family found to have lived in man-made structures.

The larger dens containing numerous tunnels were probably the result of many years of continued use (Egoscue, 1956, 1962, Morrell, 1972). Some of the smaller, one-entrance dens appeared to have originally been badger diggings. A few were located on old kangaroo

rat (Dipodomys) mounds. McGrew (1977) suggested kit foxes in the West Desert depended on other burrowing animals, particulary badgers, for a start for new dens, and if soils could not be burrowed, then alternate shelters were used. Kit foxes have been described as both poor diggers (Cahalene, 1947) and excellent diggers (Lechleitner, 1969). Observations made during this study tend to support the latter.

Two natal kit fox dens, not otherwise used in this study, were entirely excavated in order to obtain pups for laboratory studies, and this provided an opportunity to examine the internal structure of a kit fox den. The first den consisted of a series of spiraling, inter-connecting tunnels that led to two grass-lined chambers. The first chamber (approximately 0.6 m below the surface) was apparently used for food storage as it contained a little pocketmouse (Perognathus longimembris), an Ord's kangaroo rat (Dipodyms ordii), and the head and torso of a young black-tailed jackrabbit. The second chamber, found approximately 2.5 m below the surface, was larger and probably used for sleeping. The second den (Fig. 2) was not not as deep (only about 1.3 m below the surface) but also contained two grass-lined chambers. The food chamber contained two Ord's kangaroo rats and a northern grasshopper mouse (Onychomys leucogaster). Approximately six non-natal dens were partially excavated in order to retreive collars from living or dead foxes. Most of these dens had 3-10 entrances and extended at least 1.3 m below the surface. Seton (1925) described dens in the Mojave Desert in Arizona extending 2.5-3.0 m below the surface. Morrell (1972) described a den extending as far as 1.3 meters below the surface. If dens were otherwise

disturbed (e.g., if one or more entrances were blocked or caved in), foxes would move to a another den that night. Most dens were older, established ones, but on occasion new dens were dug. On one occasion, a striped skunk was trapped outside a known kit fox den. The former resident and her juvenile offspring were found the next morning in a freshly dug two-entrance den some 100 m away. A radio-collared pair from an excavated den were tracked the following morning to a 10-entrance den, which appeared to have been dug overnight. Such activity would support the idea that kit foxes are excellent diggers, at least in some circumstances. Often when a den change was made, a definite shift in home range to the area surrounding the new den was observed. This suggests that one reason for den changes may be to move closer to an area of more available prey. External parasite loads, particulary fleas, often decreased temporarily after a den change. Another reason, therefore, for den changes would be to leave a den containing infestations of external parasites such as ticks and fleas. Total number of den changes was as high as 33 for males and 19 for females. Dens occurred in groups or clusters, with 7-17 dens in each cluster ($\underline{x}$ = 9.5, $\underline{S}$ = 4.0), and were not randomly scattered (Table 2). All dens used by a particular family of foxes were considered to be in that family's cluster. Each cluster of dens was never more than 2 sq. km in size and most dens in a cluster were never more than 100 m apart.

All natal dens were located in raised, well drained areas as close as 1.5 km to each other. The number of entrances ranged from 3 to 10. Seven species dominated shrub cover at natal den sites (Table

3). Shadscale with its spiny protection resists grazing pressure by sheep and cattle. As a result, relative dominance (85.2%) was highest for this species in paddocks under heavy winter-spring grazing by sheep (Table 3). Low rabbitbrush was the dominant shrub for Dens 4 and 6 ($\underline{x}$ height = 14.7 and 14.2 cm, respectively). Common winterfat was the dominant shrub for Den 1 ($\underline{x}$ height = 17.9 cm), desert molly (*Kochia americana*) dominated the Den 2 site ($\underline{x}$ height = 10.1 cm) and fourwing saltbush (*Atriplex confertifolia*) dominated the Den 5 site ($\underline{x}$ height = 31.9 cm). Cluster analysis of natal den sites based on similarities of relative dominance of shrub species combined Dens 1 and 6 to give the highest similarity index (80%) followed by Dens 1 and 4 (63%). Dens 1 and 3 were combined to give the lowest similarity indices (8%). Cluster analysis of natal den sites based on similarities of average shrub height combined Dens 4 and 5 to give the highest similarity index (60%), followed by Dens 1 and 6 (42%). Dens 1 and 3 were combined to give the lowest similarity index (9%). According to McGrew (1977), most kit fox sightings in Utah occur in the salt desert type (*Atriplex* sp. zone) followed by southern desert shrubs (*Larrea spp.*, *Coleogyne spp.*). Grass cover at natal dens ranged from 5.9% (Den 1) to 15.7% (Den 5). Forb cover was even lower, ranging from 2.5% (Dens 4, 5 and 6) to 7.7% (Den 1; Table 3). The most important characteristic of kit fox habitat appears to be the vertical and horizontal structure (i.e., height and width) of vegetation (McGrew, 1977). Grasses and forbs at unused dens appeared to be more dense than the surrounding area, perhaps as a result of increased nutrients from fox scat (Egoscue, 1962), soil disruption from digging, or better drainage due to the deposition of soil from

den excavation (Golightly et al., 1982). Vegetative cover at active dens appeared to be less than the surrounding area, probably due to constant trampling by foxes. Soil texture at Den 2 was a sandy clay loam, while textures at the other five natal dens were all rated as sandy loams. Similar soil textures were reported by Egoscue (1962) and Morrell (1972) at their study sites. Average year-round temperature for average maximum den depth (130 cm) was 14.0 C providing a comfortable environment (Holmgren, personal communication; Fig. 3). The amount of shrub cover apparently affects soil temperature up to a depth of approximately 40 cm (Holmgren, personal communication). Since shrubs are less abundant at den sites, soil temperature would be warmer at these sites compared to surrounding sites in the summer, and colder in the winter.

Body Development and Condition Assessment

Kit foxes breed near the first of January (Egoscue, 1956). All vixens that had whelped had the distinctive, reddish-colored fur around their mammary nipples, an indication of lactation (Egoscue, 1975). The coloration did not completely disappear until acquisition of winter pelage in late summer and was not present on the female helper at Den 1. Whelping occurred from mid-March to mid-April. Approximate whelping dates were 22 March for Den 1, 12 March for Den 2, 15 April for Den 3, 19 March for Den 4, 14 March for Den 5 and 13 March for Den 6. Litter sizes ranged from 3 to 7 pups with an average of 4.6 pups/litter. The sex ratio of pups was almost 1:1 (15 males:14 females) indicating a fairly stable population. Egoscue (1975) suggested a high male:female ratio would indicate an overcrowded

situation, while a high female:male ratio tends to speed population recovery. The typical litter sizes of 3-7 pups and the fact that all adult females trapped were found to be lactating gives further evidence of a fairly stable population (Egoscue, 1975).

Average weight gain/month for pups was 462 g for males and 353 g for females, compared to 464 g for the laboratory-reared male and 456 g for the laboratory-reared female. A weight gain ranging from 340 to 456 g/month for San Joaquin kit fox pups was reported by Morrell (1972). Measurements taken in June (Dens 1-2 and 4-6) and July (Den 3; because of the late whelping date) were used for comparison between pups (Table 4). Even though the pups were still growing at this time, most were still alive and none had yet dispersed. In order for pups to be compared at approximately the same age (3 months), the June or July date of each measurement used for between-den comparisons depended upon the whelping date of each den of pups. With the exception of ear length, juvenile males surpassed females in all body measurements. The only significant differences between mean body measurements of male and females pups were weight, tail length, and zygomatic breadth (Figures 4 and 5). Only weight and condylobasal length were significantly different between male pups of the six dens and there were no significant differences in mean body measurements between female pups of the six dens. While most body measurements began leveling off by mid-August, weight continued to increase for non-dispersing pups until around mid-October. Adult males surpassed females in all body measurements (Table 4), though only hind foot length was significantly different. Average weight of the two sexes

was close, probably because two females were weighed while still pregnant.

A body condition index (CI) was calculated for each adult male fox (Table 5) and juvenile (Table 6) by using the following formula.

$$CI = \frac{WixTixCixZi}{WmxTmxCmxZm} x100 \quad \text{where:}$$

i = measurements for individual foxes
m = maximum value for fox of appropriate age and sex
W = body weight (kg)
T = total length (mm)
C = condylobasal length (mm)
Z = zygomatic arch width (mm)

Condition indices were not calculated for adult females because of weight discrepencies between females trapped only before whelping and those trapped only after whelping. Size of home range can be incorporated directly into the CI for adult males by using a mutiplier ratio derived as follows.

$$HR = 1 - \frac{HRi}{HRmax} x\ (100) \quad \text{where:}$$

HR = Inverse ratio of proportional home range size
HRi = Size of home range (sq. km) of the i-th male fox
HRmax = Largest home range (sq. km) of all male foxes monitered

A condition index that reflects the negative aspects of home range size is calculated by HR x CI/100 (Table 5). Kit fox males with high CI values were not recorded as mortalities. The Den 1 and 2 adult males, who had the two lowest condition indices (16.4% and 27.3%, respectively), both died of unknown causes. A relationship appeared evident between CI values (Table 6) and unknown factors causing mortality among kit fox pups prior to dispersal. Female pups 219

(Den 2) and 228 (Den 6) had the two lowest CI values (50% and 63.2%, respectively) and were the only two females to die of unknown causes prior to dispersal. None of the male pups, prior to dispersal, died of causes that could be related to low CI scores. No significant correlation was found either between numbers of nucleated red blood cells or lymphocytes and the level of condition index in either adult or young foxes. In fact, some of the pups and adults with higher numbers of nucleated red blood cells also had higher CI scores. This may be in part due to the fact that not all blood samples were drawn in the same period of time. There did not appear to be any significant correlation between external parasite loads and CI values. There was a strong negative relationship between condition indices of adult males and litter size of pups in June, since larger litters probably place increased demands upon parents for food and other provisions than smaller litters.

Assessments of external and internal parasites of kit foxes indicated these organisms could influence the observed rate of mortality with or without directly causing death. External parasites included fleas (representing three families), small biting louse (Trichodectes canis) and ticks (Haemaphysalis sp.). Parasite loads increased in early summer and remained at medium to high levels until late summer. There were significant (P 0.5 chi square) differences between dens regarding degree of infestation of resident foxes for fleas, ticks and lice. Foxes in Den 2 had the highest overall mean external parasite load for all 3 external parasites (1.3 on a scale from 0 to 3) and Den 4 had the lowest (1.1).

Test samples of 24 foxes (12 adults and 12 juveniles) indicated fecal material contained many detached proglottids from tapeworms, as well as eggs of nematodes. Three adult foxes (one male and two females) were sacrificed (December 1983) for examination of internal parasites. Eight specimens of the nematode *Physaloptera rara* were found in stomachs of these foxes. The large intestines of all three foxes supported large infections of tapeworm cestodes (*Taenia* sp.). In two foxes, the intestines were nearly blocked with adult cestodes. The observed rate of infection of the three sample foxes would cause problems from ulceration of the epithelial lining of the intestines, as well as loss of nutrients through decreased functional effectiveness of the intestines.

Analyses of white blood cell differentials were performed on 33 of the 42 study foxes (Table 7) and on two laboratory-reared foxes (Table 8). The average white cell differential for all wild foxes was as follows: polysegmented neutrophils (79.8%), neutrophils (band; 0.3%), lymphocytes (15.9%), atypical lymphocytes (0.4%), monocytes (3.2%), eosinophils (0.03%), and basophils (0.03%). Also present was an average of 2.5 nucleated red blood cells/specimen (Table 7). Premature release of these immature red blood cells into the blood stream is usually indicative of anemia, often hemolytic, and may be attributed to poor diet, heavy parasite loads or both (Bauer et al., 1974).

Results from blood analyses of the two male and female foxes reared in the laboratory differed considerably from those obtained from foxes in the field. Average results for these foxes were as follows (Table 8): polysegmented neutrophils (62.5%), lymphocytes (36.5%), and monocytes (1%). No nucleated red blood cells were seen (Table 8). This difference in white blood cell differentials was probably due to the two different environments in which the pups were reared. Laboratory-reared foxes were dusted for external parasites and treated for internal worms. Normal values for dogs (Schlam et al., 1975) are as follows: segmented neutrophils (60-77%), neutrophils (band; 0-3%), lymphocytes (12-30%), monocytes (3-10%), eosinophils (2-10%) and basophils (rare). The cause for the higher than average percent of segmented neutrophils (and therefore a higher neutrophil:lymphocyte ratio) in the wild foxes is unknown. Bacterial infections are known to cause an increased percentage of immature neutrophils (bands; Bauer et al., 1974, Schlam et al., 1975), though there was no sign of infection in any fox when blood samples were taken. Though lymphocyte percentages for most foxes was within normal range for dogs, 10 foxes were below this range. One known cause of such low lymphocytes percentages in canines is distemper (Schlam et al., 1975). It is not known if any foxes had this disease, though an autopsy on the Den 5 adult male revealed discoloration of the lungs, sometimes an indication of distemper.

Home Range And Prey Assessment

The average home range size for adult male foxes was 2.3 sq. km, compared to 1.8 sq. km for adult females (Table 9). Morrell (1972) reported the San Joaquin kit fox spends its entire life in an area of 1.6-3.2 sq. km with much overlap in home ranges. Four of the six study dens had at least some overlap in home range at different times during the study. Figure 6 shows home range shape and size of the Den 4 adults over the course of 11 months.

Females tended to remain closer to their natal dens during whelping and for approximately 2 weeks thereafter. The female helper at Den 1 remained even closer to the den than did the mother. Although home range area increased or decreased seasonally, such changes varied from den to den and no seasonal trend could be detected. Home range size may be partly influenced by washes within the home range. A strong negative relationship existed between total length of all washes within a home range and home range size. One possible explanation is that if prey were more adundant in these washes, then a larger foraging area would not be needed. Females that lost mates did not appear to range any further than females with mates. Paired foxes did not usually hunt together. Some foxes hunted in the same area for several nights before changing to another area of their home range, apparently responding to their success at capturing prey.

Juveniles began leaving the immediate area of their dens accompanied by their parents in early and mid-July. Occasionally, the entire family hunted together, but parents usually hunted separately, each taking some of the pups with them. After a trial period lasting

no more than a week, whelps began hunting on their own. Home ranges from July-November averaged 1.2 sq. km for non-despersing and late despersing juveniles.

Clustering of home ranges based on similarities between percent presence of major grass, forb and woody species combined the home ranges for foxes in Dens 1 and 4 to give a similarity index of 68%, followed by Dens 2 and 5 (61%; Fig. 7). Dens 1 and 4 were combined with Den 6 to give a similarity index of 54%. All dens showed 40% similarity in major plant species. One possible explanation of such a high correlation between Den 1 and Den 4 home ranges is their close proximity to each other as well as some degree of overlap, particularly in late summer and fall.

Leporid transects were assessed in May, July, and October. Average densities are given in Table 10. Small rodent transects were assessd in late May and early June. Transects for Dens 4 and 6 were repeated in mid-September due to unsatisfactory results obtained in June. The number of small rodents trapped was low (usually only a 1-8% success rate) resulting in low population estimates of density. Part of the low success rate may have in part resulted from foxes defecating and urinating on some of the traps. Small rodents trapped included the Ords kangaroo rat, little pocketmouse, deer mouse, northern grasshopper mouse, and antelope ground squirrel (_Ammospermophilus leucurus_). Despite known abundance in years past, no chisel-tooth kangaroo rats (_Dipodomys microps_) were trapped, found in fox scat, or otherwise observed. This kangaroo rat is known to comprise portions of kit fox diets in other areas (Egoscue, 1962).

Assessment of bird transects in late July revealed mainly the horned lark (Eremophilia alpestris), followed by the common raven (Corus brachyrhynchus), house wren (Troglodytes aedon), and swallow sp. (Hirunidae sp.). Horned lark densities were greater than expected and may be a result of the horned lark's tendency to congregate at roadsides. Other prey items, such as the mourning dove (Zenaida macroura), and the black-billed magpie (Pica pica), were not found in the census, probably because the census was conducted after their migration. A summary of estimates of potential avian prey populations is shown in Table 10. The transect for Den 3 contained the highest diversity (MacArthur and Wilson, 1963) of potential prey species (39%) followed by Den 1 (33%), and Den 4 (15%). Transects for Dens 2, 5, and 6 all had a species diversity of 9%.

Food Habits

Diets of adults and larger juvenile kit foxes on the DER appear unique in that strong dependence on a single species is not shown (Table 11). Dominant food items in diets varied considerably between dens of foxes in winter-spring (W-SP) as well as summer-fall (S-F) seasonal periods. Black-tailed jackrabbits ranked first in average percent relative frequency (21.1%, CV = 49.3%) in W-SP diets but ranked second (18.3%, CV = 33.7%) in average S-F diets. The Ord's kangaroo rat ranked first in average percent relative frequency (21.9%, CV = 52.5%) during S-F and dropped to third ranking (17.1%, CV = 43.8%) in W-SP diets. This is the first study to document horned larks as a major prey item for kit foxes. Horned larks ranked second in percent relative frequency (18.5%, CV = 64.9%) in W-SP diets, but

dropped to fifth ranking (9.5%, CV = 96.8%) in S-F diets. Foxes in Den 5 showed distinct variability regarding dietary dependence on horned larks. Diets of these foxes showed horned larks ranked first in percent relative frequency (39.5%) in W-SP diets, but were not detected in diets sampled in the S-F period when these foxes switched to black-tailed jackrabbits and Ords kangaroo rats as major prey items (Table 11). Jerusalem crickets (Stenopelmatus fuscus) were surprisingly strong year-round components of kit fox diets. These insects ranked fourth in percent relative frequency (14.4%, CV = 67.4%) in W-SP diets and increased to third ranking (20.6%, CV = 57.8%) in S-F diets. Evidently, the fossorial habits of these crickets, as well as scorpions (Centruroides spp.), allow kit foxes to locate them either by digging or within the subterranean chambers of active and inactive dens. Young pronghorn (Antelocapra americana) remains found around the dens were probably carcasses resulting from many forms of mortality.

Cluster analysis for similarity indices on adult W-SP diets (Fig. 8) combined Dens 3 and 4 with a similarity index of 67%, followed by Dens 1 and 5 (57%). All dens showed 44% similarity in diet. Cluster analysis for similarity indices on adult S-F diets (Fig. 9) combined Dens 2 and 6 for a similarity index of 64%, followed by Dens 2 and 6 with Den 5 (55%). All Dens showed 43% similarity in diet. Den 5 had the highest similarity index between W-SP and S-F diets (62%), followed by Den 2 (49.3%), Den 1 (38.8%), Den 6 (34.2%), Den 3 (32.6%), and Den 4 (30.3%). If adult male body condition (CI) is representative for a pair at each den, it is notable that Den 4 and

Den 5 foxes, with the highest indices of body condition (Table 5) followed quite different strategies in dietary selection during W-SP and S-F seasons. Apparently, adult kit foxes can select optimal diets from a wide array of prey items in their home ranges, that are present in far different levels of abundance. Results of similarity indices between prey availability and relative percent frequency of prey in adult diets revealed Den 1 as having the highest similarity indices (40.4%) followed by Den 1 (36.4%), Den 2 (28.7%), Den 4 (27.3%), Den 3 (22.5%), and Den 5 (8.8%).

Analysis of pup scat showed similar results in average percent relative frequency of prey items. There was a heavy reliance on not only Ords kangaroo rats, but also horned larks and Jerusalem crickets (Table 12). The Ord's kangaroo rat ranked highest in mean percent (16.4%, CV = 53%), followed by the horned lark (15.3%, CV = 14.8%), and the little pocketmouse (14.1%, CV = 83.6%). The majority of black-tailed jackrabbits were probably brought to dens by parents, since pups were not large enough at the time to kill these hares on their own. This may explain why black-tailed jackrabbits constituted an average of only 8.2% of pup diets. Cluster analysis for similarity indices on juvenile diets (Fig. 10) combined Dens 2 and 6 for a similarity index of 61%, followed by Dens 1 and 3 (46%). All Dens were combined to give the lowest similarity indices (25%). Similarity indices between prey availability and relative percent frequency of prey in the diet was somewhat higher for pups. Den 6 had the highest similarity indices (53.2%), followed by Den 2 (46.0%), Den 1 (43.4%), Den 3 (29.0%), Den 5 (24.0%), and Den 4 (10.1%).

Most hare remains found in and around dens appeared to be those of immature individuals. Egoscue (1962) noted kit foxes have considerable difficulty killing adult jackrabbits and, Cutter (1958) reported jackrabbit and cottontail remains found in stomachs and scat remains of the swift fox (*Vulpes velox*) were all immature. Thus, most black-tailed jackrabbits killed during this study were probably juveniles.

The only item not found in the scat analysis, but observed at a den site, was the remains of a great horned owl (*Bubo virginianus*) at Den 2. The den was not near any power poles or heavily traveled road, and the owl was probably sick or dead when encountered by the fox. Pups at Den 4 were observed chasing and eating moths shortly before sunset and were also observed scavenging two striped skunk carcasses. Additionally, scat not belonging to any of the study foxes was found to contain pieces of horned lark egg shells.

Kit foxes are considered opportunistic foragers (Egoscue, 1962, Laughrin, 1970, Morrell, 1972), but there is also evidence of dietary specialization. Laughrin (1970) and Morrell (1972) observed dietary habits of *V. m. mutica* were dependent on distribution and abundance of kangaroo rats. Egoscue's (1962) studies of *V. m. nevadensis* in Utah reported kangaroo rats abundant in areas occupied by foxes, but utilized for food far less than expected. His (Egoscue, 1975) more recent studies support the idea that dietary dependence of *V. m. nevadensis* on black-tailed jackrabbits is significant and reproductive success of kit foxes is correlated to the fluctuating abundance of these hares.

Dispersal

Dispersal for juveniles began in mid-August and continued through early November. Straight-line distances traveled from natal dens, for these foxes located by radio-telemetry, varied from 24 to 64 km . In almost every instance, each dispersing fox was found in a mountainous area at least part of the time. One female remained in the foothills of the west slope of the Wah Wah mountains before crossing the range and entering Wah Wah valley for a total of 64 km before being killed by a coyote. A dispersing male crossed the Mountain Home Range approximately 27 km southwest of his den and was found dead on the west slope of the range, apparently having been caught in a snow storm. Yellowish bone marrow suggested that malnutrition may have been a contributing cause of death. Another male, the first fox to disperse, traveled to Middle Mountain, approximately 24 km northeast of his den, and remained there 2 days before traveling to the Tunnel Spring mountains, 9.6 km to the west. He was found 3 days later, apparently killed by a coyote, only 1.6 km south of his original den. This was the only dispersing juvenile known to have returned to the area from which it originally dispersed. Both this male and the previously mentioned female were living in rock crevices during their dispersal. The only fox (a juvenile male) found inhabiting a desert floor area during dispersal did so for approximately 2 weeks. During this time, he occupied three different sites (which appeared to be old badger diggings), approximately 26 km southeast of his original den before disappearing. He was found later, in early December, in a cattle watering tank under approximately 30 cm of ice. This site was

located in a Pinyon-Juniper area in the south end of the valley approximately 45 km southeast of his original den. Egoscue (1956) reported a distance of 32 km traveled both by an adult female kept as a pet and another young fox. Of the 12 dispersing radio-collared juveniles, the eight eventually located were found dead suggesting that dispersal carries a high mortality rate. Death may result from increased energy demands from travel, inability to capture prey in various new habitats, increased exposure to predators (e.g., coyotes), lack of shelter, or competition from other foxes for food and shelter. Dispersing foxes may also be captured in traps, since trapping season and dispersal tend to coincide, though none were reported by trappers.

At the same time juveniles were dispersing from the study area, six new foxes, mostly juveniles (four males and two females) were trapped in the study area. One juvenile male alternated between a den occupied by the Den 2 female (who had lost her mate in August), and a den occupied by her juvenile daughter. Another juvenile male was found with a newly arrived juvenile female at the Den 5 natal den. A third newly arrived juvenile male was radio-collared and remained with a Den 3 juvenile female for 2 weeks before moving on to an unknown location. A fourth male (adult) was found with the Den 1 adult female who had lost her mate in May. Whether this association, if any, was to last is not known since the female was found dead a week later of unknown causes, and the male was never seen again. A second juvenile female was trapped and radio-collared at a den site occasionally occupied by Den 4 foxes. This female was found to alternate between this den and 1 km west in a rock crevice near the top of a steep

ridge. The reasons for occupation of seemingly uncharacteristic habitats such as mountainous, rocky areas by emmigrating and immigrating individuals could be avoidance of other foxes or greater availabilty of prey in these areas. Also, less energy would be required to live in an already established shelter than to dig a new den or clean out an old one. For example, a transient adult male was trapped in April near an abandoned den, but continued to inhabit a rock crevice on a nearby steep ridge. V. m. arsipius has similarly been found in the high, rocky, juniper-covered hills of the Mojave desert (Grinnell et al., 1937). No mortalities were found in any of the newcomers. Egoscue (1975) did not detect an influx of newcomers and attributed it to the possibility that newcomers were either avoiding areas occupied by adults or were avoiding the traps.

DISCUSSION AND CONCLUSIONS

A prenatal shuffle, occurring up to 1 week before whelping in March, was evident for fox pairs in Dens 1 and 3 and involved a series of movements that separated and reunited members of each mated pair. One possibile reason for such shuffling may have been a search for a natal den, since kit foxes are known to clean out and inspect most usuable dens before selecting a natal den (Egoscue, 1962). In early May, another type of separation and reuniting behavior began to take place at all dens. The male would leave the female and pups and move into a nearby den for up to 1 week at a time. This was not abandonment, for the male still helped in providing food for the female and/or young. Perhaps this behavior allowed the male to rest better in the daytime without the annoyance of the begging whelps

and/or female. Morrell (1972) also reported this behavior in the San Joaquin kit fox. As the pups grew older, the male and female still occasionally separated, but each would take some of the pups to their respective dens. Family units did not really break up until pups began dispersing in August.

Non-dispersing juvenile females continued to periodically live with or nearby their parents and/or their siblings at least until the study ended in December. Female inclusive fitness may best be served by juvenile females remaining in the natal home range as helpers for a year before reaching sexual maturity. By using this strategy, these females may eventually take over portions or all of the natal home range, a form of territorial budding (Woolfenden and Fitzpatrick, 1978). Egoscue (1975) noted that more pups tend to remain instead of dispersing when adult numbers are low. Apparently, enough adult males entered the study area to replace adult males that died. Our data suggest a high mortality rate for males.

Visitation between foxes was observed on several occasions. In early June, an adult female was trapped at a den being used by the Den 2 foxes, indicating that female visitation to a den occupied by other foxes occured at least on one occasion. An adult male (ear tagged in March along with his mate at their nearby natal den) was trapped in November at a den periodically used by the Den 4 foxes. This was the first time since March this male had been trapped, though weekly trappings took place in this area for Den 4 pups, suggesting that he may have been expanding or shifting his home range in search of food and/or a new mate. On two occasions, during post-whelping separation

of pairs, male foxes were found with other foxes. In early June, the adult male from Den 1 was found with a fox whose sex was unknown (due to an inability to trap). In early September, the Den 3 adult male was found with the Den 1 adult female (who had lost her mate) and her juvenile daughter. The adult female moved the next day, but the male remained with the juvenile female for 2 more days before moving back with his own mate and whelps. Such visitations suggest that non-aggressive contact with other foxes is made by members of mated pairs. Spatial-temporal scent marking (Mech, 1970) occurred but did not apparently serve to establish or maintain exclusive hunting territories for mated pairs. Perhaps such an expanded social structure serves to allow contact between male and female foxes who have lost mates during breeding season. No evidence was found that visitations (by males or females), took place immediately before, during, or after whelping. Also visited and marked with feces and urine were surrounding dens not being used at the time. Visitation and marking of unused dens could be a survey of available dens or a search for prospective mates by unpaired individuals (Egoscue, 1956). Kit foxes, therefore, do not appear to be strongly territorial but instead appear to have an expanded social structure with a dominance hierarchy between foxes that parcels out best den sites and determines those foxes allowed to stay in occupied areas. The expanded social structure may indicate a reduced level of competition between kit foxes, but discovery of the transient male in April suggests that sufficient space still may not be available for non-mating individuals. All surviving pairs were still found together when the study ended in December, suggesting they were again continuing the

pair bond for the following year. Kit foxes are said to be monogamous (Ingles, 1958, Egoscue, 1956, 1962). They do not breed successfully their first year and non-breeding males are solitary (Morrell, 1972).

For adult males, there was a significant negative correlation ($\underline{r}$ = -0.88) between condition index (CI) and home range size. This negetative correlation supports the reasoning that a large home range for foraging may exceed optimal limits. The consequential error of exceeding optimal limits will be reflected in reduced scores of body condition (CI). Data for the Den 5 male was not used in this correlation since he died 42 days after initial capture and before his home range could be adequately assesed. Condition indices were high for the Den 5 adult female inspite of having to rear six pups on her own. The presence of numerous washes (9 km washes/1.4 sq. km) in her home range may have provided more microhabitats for prey resulting in reduced search time and energy needed for locating prey. The high CI scores of foxes at Den 4 may be explained by the fact that these foxes frequently hunted around both inhabitated and uninhabited buildings where more rodents might be expected to live, resulting in reduced time and energy spent in hunting.

Kit foxes began hunting and related activities as early as 1 hour before sunset but always ended at daybreak. Tracks left in snow tended to meandor back and forth in an optimal foraging pattern that minimized path crossing, but effectively explored the foraging area (Cody 1971). Several hare kills were found and judging from tracks in the snow, it appeared hares were stalked and killed rather than caught during a chase. Prey caught by kit foxes may be entirely eaten on the

spot or parts of it may be cached or taken back to the den (Egoscue, 1962, Grinnell et al., 1937). Shrub patches were apparently selected and searched in an attempt to locate available prey. Both heavy snow and rain appeared to limit kit fox hunting. Hunting would take place for only a short portion of the night or not at all during such inclement weather. Both kit fox and coyote tracks were at times found on the same trails, and it did not appear that foxes were avoiding coyotes.

Kit foxes apparently obtain all the water they need from their prey (Egoscue, 1956). The cool, moist microhabitat of their dens probably keeps water loss to a minimum. Reliance on evaporation for heat dissipation is minimal probably as an adaption to water scaracity in the desert environment (Golightly and Ohmart, 1983) thus further reducing the need for water. They will, however, drink free water if available. Dens 2 and 4 were located near permanent water supplies (antelope water troughs), and foxes from these dens were seen drinking water from them though their foraging patterns did not appear to be centered around these water sources. The laboratory-reared foxes also drank free water regulary. More prey is needed in summer to satisfy water requirements than needed to satisfy energy requirements (Golightly and Ohmart, 1983). An increase in mortality rates in the summer may be the partly attributed to an inability to meet this increased demand for prey.

Approximately 2,200 sheep and 300 cattle graze portions of the DER from 29 November to 5 April. Kit foxes did not appear to react to the presence or absence of sheep or cattle. Foxes would leave dens in a normal manner, even in close proximity to sheep, and hunt in their established areas with no apparent reaction to bedded or grazing sheep. They appear to react to cattle and pronghorn in much the same way. This relationship is important since over 75% of kit fox habitats in Utah are used for grazing by livestock (McGrew, 1977). Selection of kit fox habitat appears to be limited to low shrub types of vegetation, though there does not appear to be any preference for one vegetative type over another, or in grazing intensity within low shrub vegetation.

An optimal population model for an ESS (evolutionary stable strategy; Smith and Price, 1978) for kit foxes appears to include four major areas. First, a male or female kit fox must secure an upper level of dominance within the expanded social structure. Immigrant individuals arriving must find a position in this social dominance hierarchy in order to be allowed to stay. Helpers at dens with whelps may be related or unrelated to the mated pair they are helping. Helpers are probably immature females that were unable to find an unoccupied area. We do not know if male helpers are allowed. Apart from maximizing fitness by aiding relatives, there are very good selfish reasons for helping. Related helpers and non-related helpers may eventually inherit all or part of the natal home range i.e., territorial budding (Woolfenden and Kirkpatrick, 1978). Secondly, a large traditional den would be optimal in that little effort would be

required to make necessary modifications (e.g., enlargements) as opposed to small dens. A third major factor is that a smaller home range, preferably containing a large wash or numerous smaller ones, is an advantage in that less energy is expended in locating prey. Individuals with smaller home ranges appear to be in better condition (i.e., have a higher CI score) than those covering larger home ranges. Since individuals with larger home ranges suffered greater mortalities, the consequential error of foraging within too large an area appears to be death. A fourth major factor is that dispersal of young away from a natal area (as well as the arrival of new individuals into the area) apparently aids in mate replacement for males and females that lost mates after breeding season. Individuals not finding mates or open spaces in mosaics of occupied habitats may or may not be accepted as helpers. Patterns of dispersal are still largely unknown, but to be optimal, must minimize path crossing and maximize contact with other foxes.

SUMMARY

Habitat selection, reproduction, food habits, dispersal and other behavioral expressions of kit foxes on a managed desert rangeland were investigated from January 1983 through December 1983 at the Desert Experimental Range in western Utah. Six adult kit fox pairs along with a juvenile helper from six natal dens were captured and equipped with radio transmitters to document daily and seasonal movements. Twenty-nine male and female pups from each of the six dens were captured on a weekly basis to determine condition, and a male and female pup from each den were radio-collared in mid-summer to document

daily movements, and later on, dispersal. Major findings were:

1) Although coyote predation was the largest known cause of death in juveniles, most causes of death were unknown in both adults and juveniles and may be related to low body condition indices.

2) Excavated dens were larger and more complex than previously believed. All excavated dens were similar in that each had two chambers- one used for food storage, another for sleeping.

3) The sex ratio of pups (approximately 1:1) and the presence of lactating females suggests a fairly stable kit fox population occupied the study area for the duration of the study.

4) There was a negative correlation between body condition indices and home range size of adult male kit foxes. There appeared to be a strong relationship between body condition index and mortalities in pups prior to dispersal.

5) Home ranges averaged 2.3 sq. km for males and 1.8 sq. km for females. Shifts in home ranges occurred but did not appear to be seasonal. There was overlap of home ranges between foxes in four of the six dens.

6) The diets of both adults and pups appear unique in that a dependence on a single species was not shown. For the first time, horned larks were documented as a major prey item for kit foxes. Jerusalem crickets were surprisingly strong year-round components of diets.

7) Straight line dispersal distances were surprisingly long (as far as 64 km). None of the dispersing pups eventually located were found alive. Utilization of seemingly uncharacteristic habitats, such as rock crevices on mountainsides, was observed for all but one of the

dispersing juveniles.

8) An influx of newcomers on the study site, mostly juveniles, was observed during and after study juveniles had begun dispersing.

9) An expanded social system appears to exist among these kit foxes. Social visitations were regularly documented between non-mated individual kit foxes. Although scent markings were used, territoriality seemed poorly expressed.

10) Kit foxes did not react to the presence or absence of sheep or cattle, even when these animals were in close proximity to dens or established hunting areas of the foxes. Nor did they appear to react to the presence or absence of pronghorn . Habitat selection did not appear to be influenced by grazing intensity of the habitat.

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Table 1.--The known aspects of natality and mortality of male (M) and female (F) kit fox adults and pups associated with six den sites are shown below along with the known and possible causes of mortality.

	Natality			Mortality							
	Pups born		Julian date	Pups		Julian date		Adults		Julian date	
Den	M	F		M	F	M	F	M	F	M	F
1	3	1	080	1[a]	1[a]	249	270	1[b]	1[b]	121	306
					1[b]		203				
					1[b]		unk				
2	2	3	071	1[b]	1[c]	262	203	1[h]	0	227	
3	2	2	105	1[d]	1[a]	139	241	0	0		
				1[e]		342					
4	3	4	078	1[i]	1[d]	364	183	0	0		
					1[a]		304				
5	3	3	073	1[b]	1[f]	241	173	1[b]	0	161	
				1[b]		338					
6	2	1	072	1[g]	1[b]	330	182	1[h]	1[h]	340	340

[a] Coyote. [e] Possible starvation. [i] Caught by trapper.

Table 1.--(cont., p. 1)

[b] Unknown.

[c] Golden eagle.

[d] Trap-related.

[f] Injury-related.

[g] Possible drowning.

[h] Sacrificed for parasite study.

Table 2.--Total number of dens used (clusters) by each fox family and total number of times each adult male (M) and female (F) changed dens.

Den	Total dens used	Total den changes M	Total den changes F
1	7	2	14**
2	11	15***	14
3	17	33	19*
4	8	13	12
5	6	2**	18
6	8	14	10

*could not determine all den changes due to radio failure.

**Died early in the study.

***Died in late summer.

Table 3.--Kit fox den sites (1-6) are shown in relationship to grazing history of sheep and cattle as well as aspects of vegetation. The point-centered quarter method (Mueller-Dombois and Ellenburg 1974) was used for sampling woody vegetation while grasses and forbs were sampled according to Daubenmire (1959).

Den	Grazing status	Shrub species	Relative dominance (%)	Average shrub hgt. (cm)	Canopy cover Grasses (%)	Canopy cover Forbs (%)
1	Ungrazed	Common winterfat	50.0	17.9	5.9	7.7
		Low rabbitbrush	49.3	9.4		
		Broom snakeweed	0.5	12.5		
		Bud sagebrush	0.2	5.0		
2	Sheep (every other spring)	Common winterfat	24.2	19.8	11.6	4.4
		Desert molly	75.8	10.1		
3	Sheep (heavy winter-spring)	Common winterfat	13.9	14.6	12.1	4.0
		Shadscale	85.2	14.2		
		Bud sagebrush	0.8	37.7		
		Plains prickleypear	0.1	9.7		
4	Cattle (winter)	Common winterfat	30.7	14.6	14.5	2.5
		Low rabbitbrush	46.5	14.7		
		Shadscale	2.4	27.0		
		Fourwing saltbush	20.4	29.7		
5	Sheep (fall-spring)	Common winterfat	14.9	11.8	15.7	2.5
		Low rabbitbrush	17.4	19.6		
		Fourwing saltbush	67.7	31.9		

Table 3.--(cont., p. 2)

6	Cattle	Common winterfat	39.8	11.6	16.8	2.5
	(winter)	Low rabbitbrush	60.2	14.2		

Table 4.--Mean body measurements of male and female adult kit foxes and male and female pups (taken in June for pups in Dens 1-2 and 4-6; July for Den 3) and the coefficient of variation (CV %) of each body measurement.

	Weight (kg)	Total length (mm)	Tail length (mm)	Hind foot length (mm)	Ear length (mm)	Zygomatic breadth (mm)	Condylobasal length (mm)
Adult							
Male	2.1	814.0	311.3	122.8	86.5	59.2	112.7
CV (%)	5.3	7.1	7.1	1.7	2.7	2.0	0.4
Female	2.1	750.2	282.3	118.0	84.3	57.8	112.3
CV (%)	12.7	5.3	15.3	3.3	2.5	3.4	0.7
Pup							
Male	1.5	708.4	277.9	110.9	78.2	52.1	102.9
CV (%)	13.8	8.7	8.2	5.0	6.2	3.1	4.9
Female	1.4	677.9	251.6	107.2	75.7	50.4	100.3
CV (%)	13.5	6.9	8.1	3.9	4.2	4.8	3.4

Table 5.--Values for a body condition index (CI) are shown for six adult fox males along with an inverse percent of proportional home range size (HR). These values are combined (HR X CI/100) into an over-all condition index (HRCI) that reflects the inverse negative aspects of home range size for foraging male foxes.

Den	Condition index (%)	Home range factor (HR)	Condition index with home range factor (HRCI) (%)
1	75.4	0.0	0.0
2	81.2	0.20	16.2
3	88.5	0.30	26.5
4	100.0	0.33	33.0
5	94.6		
6	91.1	0.36	32.8

Table 6.--Condition (CI) indices of male (M) and female (F) kit fox juveniles calculated from body measurements sampled in June and July of 1983.

Den	Pup no.	Sex	CI (%)
1	21	M	87.0
	20	M	43.5
	211	F	71.3
2	29	M	71.3
	38	M	79.2
	221	F	89.0
	219	F	50.1
	220	F	78.6
3	37	M	79.2
	32	M	94.7
	224	F	65.5
	223	F	59.3
4	26	M	98.7
	27	M	82.3
	23	M	78.2
	213	F	74.9
	212	F	94.6
	215	F	85.9

Table 6.--(cont., p. 2)

5	30	M	100.0
	39	M	100.0
	28	M	97.7
	226	F	100.0
	218	F	89.1
	216	F	86.7
6	35	M	93.4
	40	M	87.3
	228	F	69.7

Table 7.--Results of analyses for white blood cell differentials on adult (a) and young (y) kit foxes at the Desert Experimental Range showing percent polysegmented neutrophils (Poly), banded neutrophils (Band), lymphocytes (Lymph), atypical lymphocytes (Aty lym), monocytes (Mono), Eosinophils (Eos), Basophils (Baso), and number of nucleated red blood cells (NRBC) seen. Samples were taken from late May until mid-June.

Fox no.	Age	Den	Poly	Band	Lymph	Aty lym	Mono	Eos	Baso	NRBC
810	a	1	81	0	9	2	8	0	0	4
950	a	1	82	4	8	0	5	0	1	0
630	a	1	72	0	26	0	1	0	0	10
33	y	1	80	0	20	0	0	0	0	2
20	y	1	84	1	8	0	7	0	0	2
211	y	1	85	0	15	0	0	0	0	2
530	a	2	89	0	11	0	0	0	0	0
970	a	2	84	1	14	0	1	0	0	1
221	y	2	85	0	15	0	0	0	0	3
219	y	2	70	0	26	0	4	0	0	2
220	y	2	62	0	33	0	5	0	0	4
38	y	2	87	0	12	0	1	0	0	2
29	y	2	80	0	19	0	1	0	0	2
760	a	3	82	0	15	0	2	1	0	1

Table 7.--(cont., p. 2)

224	y	3	76	0	24	0	0	0	0	5
37	y	3	86	0	14	0	0	0	0	0
32	y	3	71	0	29	0	0	0	0	0
495	a	4	83	1	10	2	4	0	0	1
212	y	4	73	0	18	2	7	0	0	2
215	y	4	83	0	16	0	1	0	0	4
214	y	4	79	0	20	0	1	0	0	3
213	y	4	74	0	10	1	15	0	0	4
23	y	4	84	2	9	0	5	0	0	2
26	y	4	92	0	8	0	0	0	0	2
27	y	4	88	0	9	0	3	0	0	1
880	a	5	89	0	7	0	4	0	0	3
216	y	5	75	0	25	0	0	0	0	4
226	y	5	78	0	17	1	4	0	0	1
28	y	5	79	0	17	0	4	0	0	5
30	y	5	68	0	21	0	2	0	0	10
39	y	5	85	0	15	0	0	0	0	1
35	y	6	78	0	6	0	16	0	0	0
40	y	6	72	0	20	4	4	0	0	0
		$\bar{x}$ =	79.8	0.3	15.9	0.4	3.2	0.03	0.03	2.5

Table 8.--Results of white blood cell differentials performed two laboratory-reared kit foxes at age 15 months (approx.) showing percent polysegmented neutrophils (Poly), banded neutrophils (Band), lymphocytes (Lymph), atypical lymphocytes (Aty lym), monocytes (Mono), eosinophils (Eos), basophils (Baso) and number of nucleated red blood cells (NRBC) seen.

Fox	Poly	Band	Lymph	Aty lym	Mono	Eos	Baso	NRBC
Male	68	0	30	0	2	0	0	0
Female	57	0	43	0	0	0	0	0

Table 9.--Average home range size (sq. km) of each adult male (M) and female (F) kit fox of the 6 study dens.

Den	Sex (M) Area (sq. km)	Sex (F) Area (sq. km)
1	3.0	2.4
		1.6 (helper)
2	2.4	2.3
3	2.1	1.4
4	2.0	1.7
5		1.4
6	1.9	1.8

Table 10.--Estimates of abundance for potential prey of kit foxes generated from periodic sampling (1983) of transects on the Desert Experimental Range in southwestern Utah.

	Kit fox dens closest to prey sampling transects					
Taxa	Den 1	Den 2	Den 3	Den 4	Den 5	Den 6
Jackrabbit[a]	26.3	29.9	19.7	23.9	29.9	21.7
sq. km						
Horned lark[b]	167.9	324.9	157.3	252.7	324.9	337.5
sq. km						
Common raven[b]	27.1	5.2	3.8	16.9	5.2	6.6
sq. km						
Swallow sp.[b]		39.0			39.0	6.6
sq. km						
House wren sp.[b]		7.8			7.8	
sq. km						
Ords kangaroo rat[c]	1.0	5.4				1.0
n/ha						
Little pocket mouse[c]	2.0		1.2	3.0	0.2	1.0
n/ha						
Deer mouse[c]	2.0					
n/ha						
Antelope squirrel[c]	0.6					
n/ha						

Table 10.--(cont., p. 2)

[a] Nearest leporid transect (vehicle) for night census (29 April-3 May, 3-8 July and 19-21 October.

[b] Nearest avian transect (vehicle) for early morning census (28-30 July).

[c] Live-trap and release census (26 May-4 June). The census for Dens 3 and 6 were repeated from 5 September to 9 September.

Table 11. Relative percent frequency of food items in winter-spring (W-SP) and summer-fall (S-F) diets of kit foxes during 1983 on the Desert Experimental Range, Utah.

Foods	Den 1		Den 2		Den 3		Den 4		Den 5		Den 6	
	W-SP	S-F	W-SP	S-F	W-SP	S-F	W-SP	S-F	W-SP	S-F	W-SP	S-F
Desert cottontail rabbit	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.0	0.0	0.0	0.0
Black-tailed jackrabbit	12.5	18.0	28.3	26.6	20.2	9.0	20.8	23.3	8.2	15.3	36.9	17.7
Botta's pocket gopher	5.6	0.0	5.7	1.1	3.0	1.3	2.7	4.6	1.3	0.4	3.4	2.1
Little pocket mouse	13.3	17.1	7.7	9.3	22.0	15.6	14.6	15.5	7.4	7.5	23.3	21.2
Ords kangaroo rat	18.2	2.4	28.1	27,6	15.2	36.0	13.8	27.3	21.5	17.5	5.9	20.3
Deer mouse	0.5	1.6	0.0	0.1	0.1	0.0	0.2	0.0	0.0	14.0	2.6	0.3
Northern grasshopper mouse	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pronghorn antelope	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Horned lark	23.6	14.2	5.2	5.5	13.4	11.6	10.7	24.4	39.5	0.0	18.7	1.1
Black-billed magpie	0.0	4.2	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.7
Common raven	0.3	0.2	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0
Lizard spp.	0.0	0.0	0.0	0.0	1.2	0.0	1.5	0.0	0.0	0.0	0.0	0.7
Scorpion	10.4	9.7	4.0	6.7	3.2	0.0	0.0	0.3	0.0	8.2	0.0	9.5
Jerusalem cricket	8.8	25.4	14.8	19.6	14.3	18.3	33.0	0.0	8.7	36.1	6.6	24.4
Grasshopper spp.	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Unknown arthropods	0.0	4.4	1.8	1.0	0.0	2.0	0.0	0.0	3.4	0.5	0.0	0.0
Vegetation	5.0	2.8	4.4	2.2	7.4	5.6	2.7	0.9	4.0	0.5	2.6	2.0

Table 12.--Relative percent frequencies of diets (until early July) of kit fox pups during 1983 at the Desert Experimental Range, Utah.

Foods	Den 1	Den 2	Den 3	Den 4	Den 5	Den 6
Black-tailed jackrabbit	12.4	22.8	36.3	13.4	13.0	21.9
Botta's pocket gopher	4.7	4.2	2.8	12.3	23.9	1.4
Little pocket mouse	26.3	2.4	32.0	15.6	0.0	8.3
Ords kangaroo rat	16.9	31.7	13.4	10.5	4.3	21.6
Deer mouse	2.8	10.2	0.0	0.0	0.0	4.2
Northern grasshopper mouse	1.0	1.2	0.0	0.0	0.0	0.0
Horned lark	0.0	24.0	2.3	0.0	32.6	33.0
Scorpion	16.6	3.6	2.8	7.7	0.0	0.0
Jerusalem cricket	9.2	0.0	0.0	30.7	26.1	0.0
Unknown arthropods	1.0	0.0	6.4	9.5	0.0	0.0
Vegetation	9.3	0.0	4.2	0.0	0.0	9.8

Fig. 1.--The Desert Experimental Range (U.S. Forest Service) is a 225 sq. km desert rangeland located in the Great Basin of southwestern Utah.

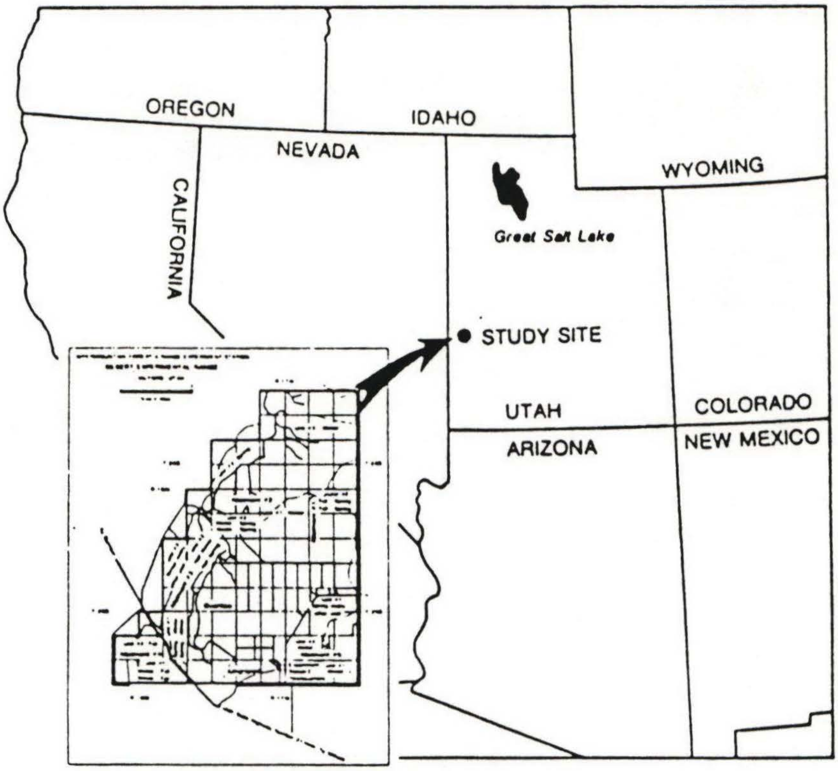

OREGON
IDAHO
NEVADA
CALIFORNIA
WYOMING
Great Salt Lake
STUDY SITE
UTAH
COLORADO
ARIZONA
NEW MEXICO

Fig. 2.--Drawing of an excavated kit fox natal den showing entrances and tunnels to the sleeping and food chamber.

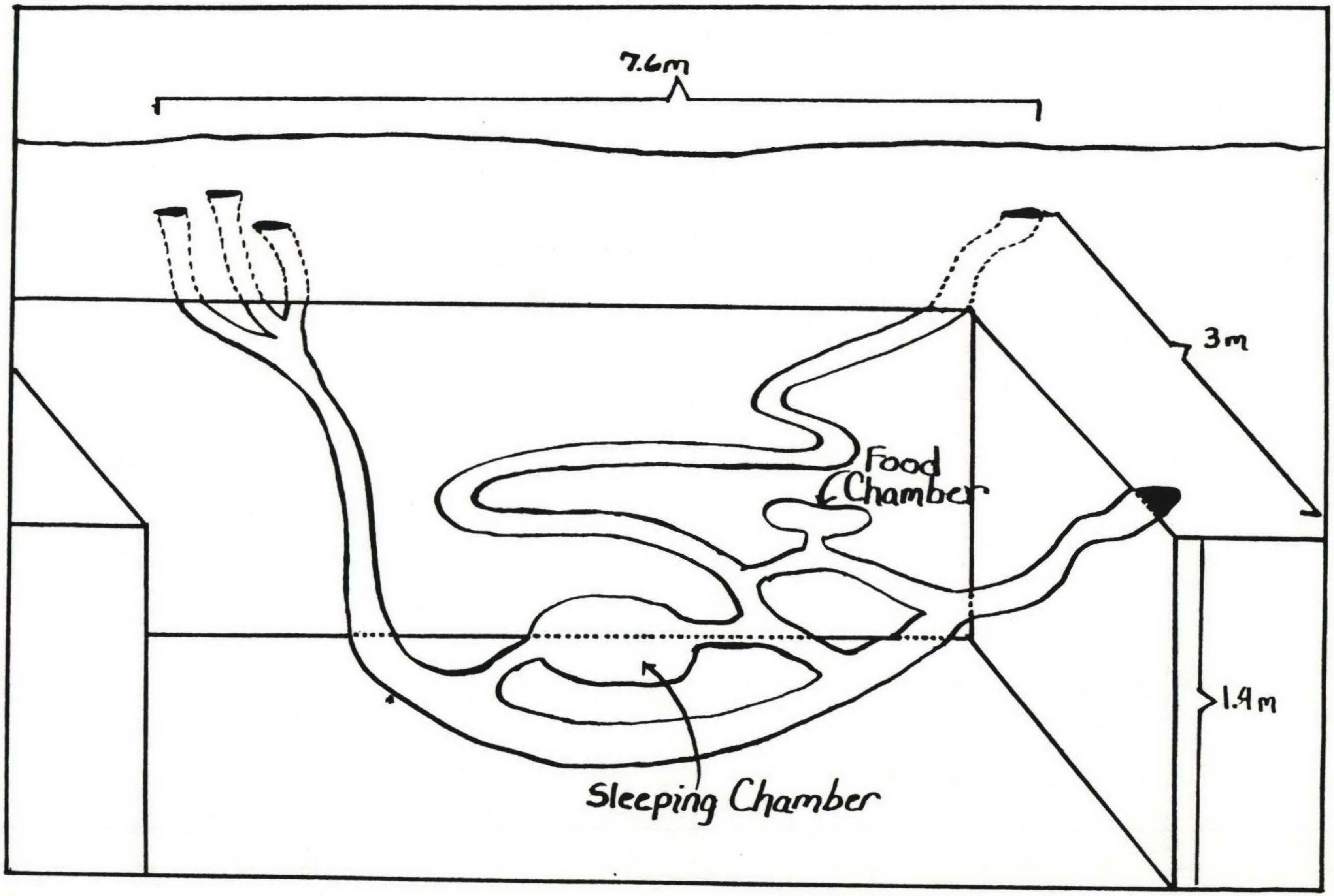

7.6m
3m
Food Chamber
1.4m
Sleeping Chamber

Fig. 3.--Soil temperatures (C) taken at varying depths and seasons at the Desert Experimental Range, Utah.

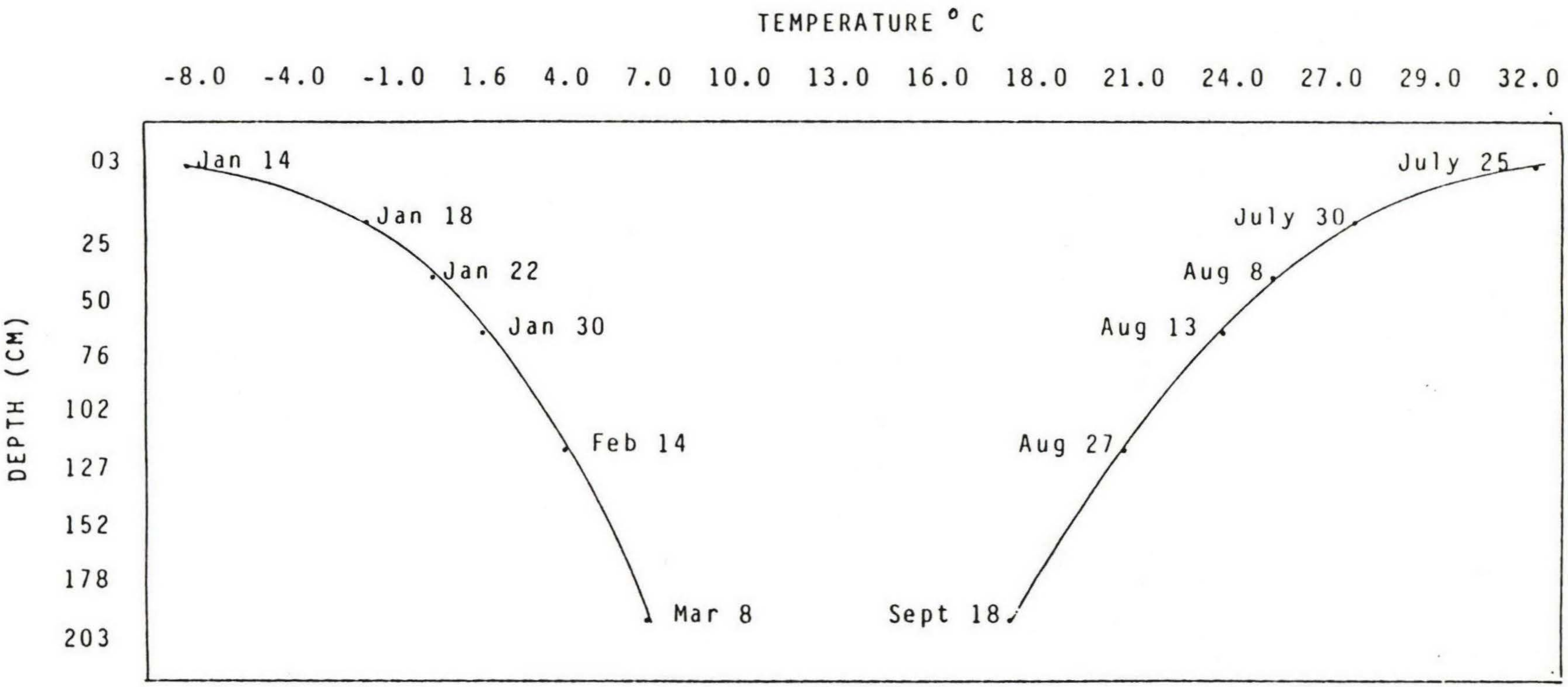

TEMPERATURE °C
-8.0
-4.0
-1.0
1.6
4.0
7.0
10.0
13.0
16.0
18.0
21.0
24.0
27.0
29.0
32.0
DEPTH (CM)
03
25
50
76
102
127
152
178
203
Jan 14
Jan 18
Jan 22
Jan 30
Feb 14
Mar 8
July 25
July 30
Aug 8
Aug 13
Aug 27
Sept 18

Fig. 4.--Comparison of total length (MM) of male and female kit fox pups plotted against days (JULIAN) from late April until early August of 1983.

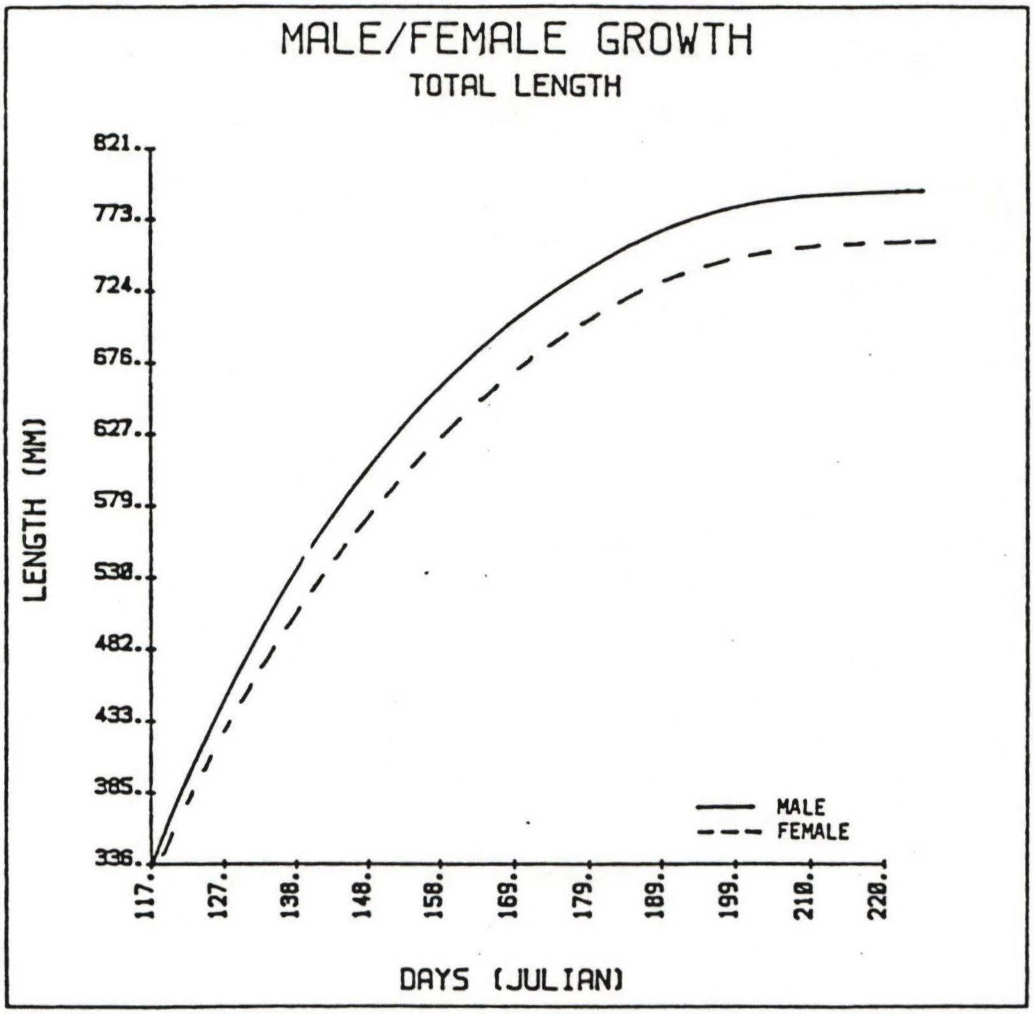

MALE/FEMALE GROWTH
TOTAL LENGTH
821.
773.
724.
676.
627.
579.
530.
482.
433.
385.
336.
LENGTH (MM)
117.
127.
138.
148.
158.
169.
179.
189.
199.
210.
220.
DAYS (JULIAN)
MALE
FEMALE

Fig. 5.--Comparison of hind foot lengths (MM) of male and female kit fox pups plotted against days (JULIAN) from late April until early August of 1983.

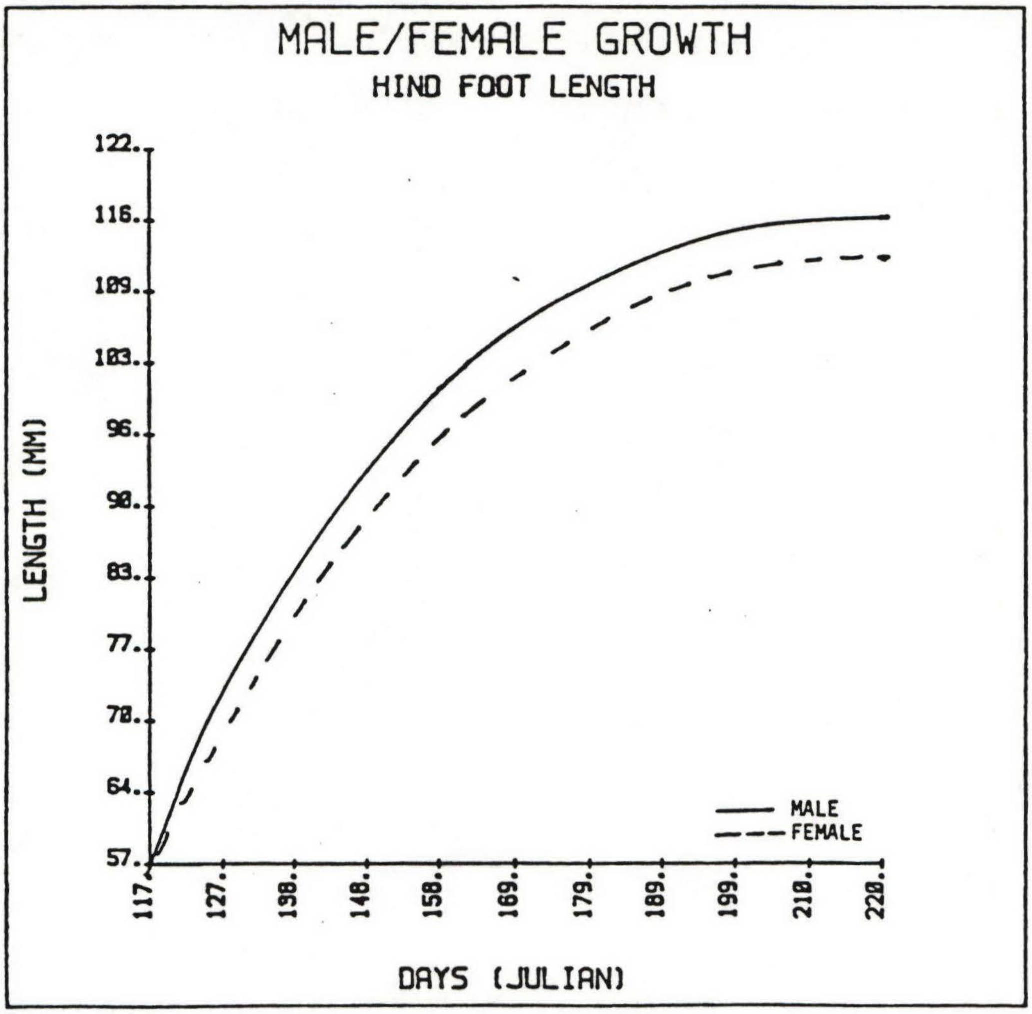
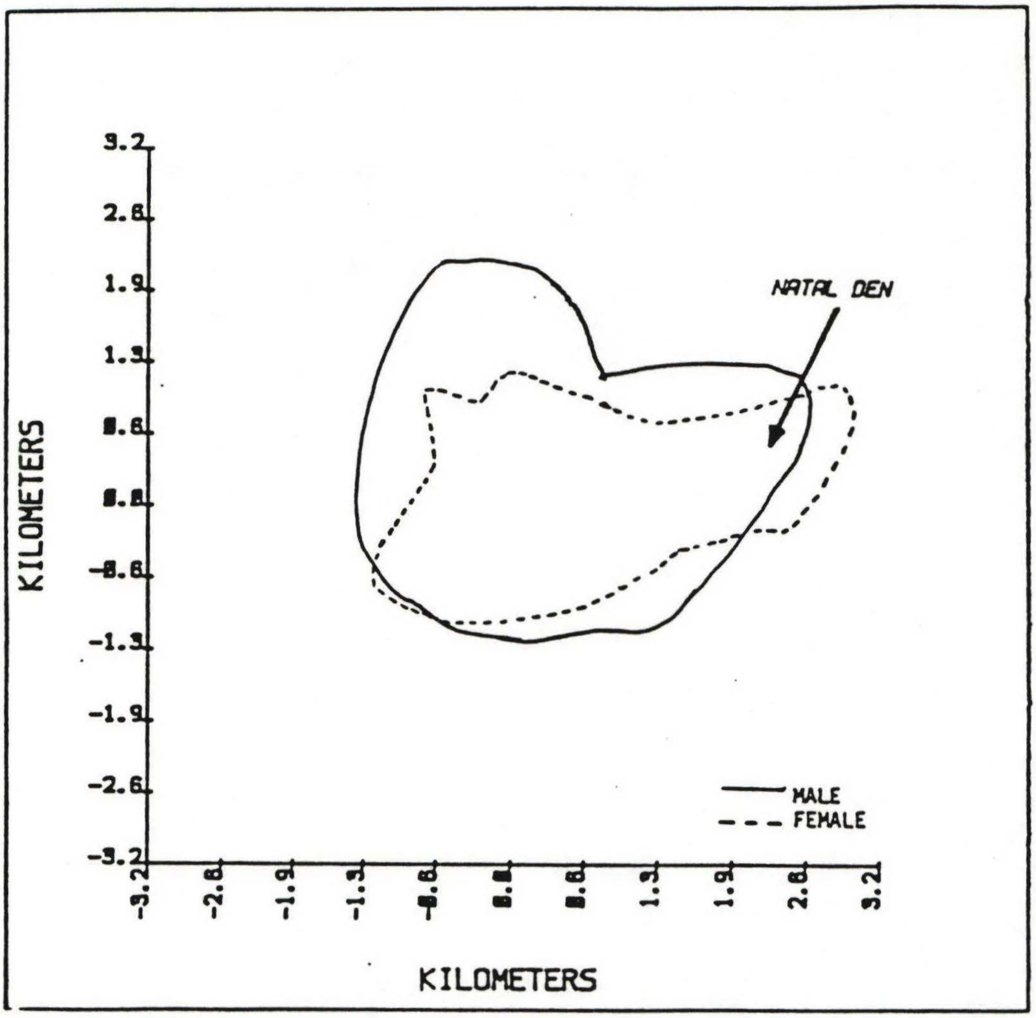

MALE/FEMALE GROWTH
HIND FOOT LENGTH
LENGTH (MM)
122.
116.
109.
103.
96.
90.
83.
77.
70.
64.
57.
MALE
FEMALE
117.
127.
138.
148.
158.
169.
179.
189.
199.
210.
220.
DAYS (JULIAN)

Fig. 6.--Home range size and shape of the Den 4 kit fox pair over the course of 11 months (February-December, 1983.)



KILOMETERS
3.2
2.6
1.9
1.3
0.6
0.0
-0.6
-1.3
-1.9
-2.6
-3.2
-3.2
-2.6
-1.9
-1.3
-0.6
0.0
0.6
1.3
1.9
2.6
3.2
KILOMETERS
NATAL DEN
MALE
FEMALE

Fig. 7.--Results of cluster analysis based on percent presence of major grass, forb and woody species in six home ranges of kit fox pairs showing den number (Den no.) and similarity index (%) of combined dens.

```
                                        Similarity Index (%)

Den

 no.                                 68%
 1*--------------------------------I
  *                                I            54%
  *                                I--------------I
  *                                I              I
 4*--------------------------------I              I     45%
  *                                               I--------I
  *                                               I        I
  *                                               I        I  40%
 6*-----------------------------------------------I        I----I
  *                                                        I    I
  *                                                        I    I
  *                                                        I    I
 3*--------------------------------------------------------I    I
  *                                                             I
  *                                                             I
  *                                        61%                  I
 2*----------------------------------------I                    I
  *                                        I                    I
  *                                        I--------------------I
  *                                        I
```

Fig. 8.--Results of cluster analysis on winter-spring diets of adult kit foxes showing den number (Den no.) and similarity index (%) of combined dens.

```
Den

no.                                67%

3*---------------------------------I

 *                                 I            54%

 *                                 I------------I

 *                                 I            I

4*---------------------------------I            I    49%

 *                                              I----I

 *                                              I    I

 *                                              I    I    44%

2*----------------------------------------------I    I----I

 *                                                   I    I

 *                                                   I    I

 *                                                   I    I

6*---------------------------------------------------I    I

 *                                                        I

 *                                                        I

 *                                           57%          I

1*-------------------------------------------I            I

 *                                           I            I

 *                                           I------------I

 *                                           I

5*-------------------------------------------I
```

Fig. 9.--Results of cluster analysis on summer-fall diets of adult kit foxes showing den number (Den no.) and similarity index (%) of combined dens.

```
                                       Similarity Index (%)

Den

 no.                                    64%

2*-------------------------------------I

 *                                     I        55%

 *                                     I--------I

 *                                     I        I

6*-------------------------------------I        I   51%

 *                                              I---I

 *                                              I   I

 *                                              I   I       43%

5*----------------------------------------------I   I-------I

 *                                                  I       I

 *                                                  I       I

 *                                                  I       I

1*--------------------------------------------------I       I

 *                                                          I

 *                                                          I

 *                                                    49%   I

3*----------------------------------------------------I     I

 *                                                    I     I

 *                                                    I-----I

 *                                                    I

4*----------------------------------------------------I
```

Fig. 10.--Results of cluster analysis on diets of kit fox juveniles showing den number (Den no.) and similarity index (%) of combined dens.

```
                                    Similarity Index (%)

Den

no.                                 61%

2*----------------------------------I
 *                                  I                          33%
 *                                  I--------------------------I
 *                                  I                          I
6*----------------------------------I                          I       25%
 *                                                             I-------I
 *                                                             I       I
 *                                                             I       I
5*-------------------------------------------------------------I       I
 *                                                                     I
 *                                                                     I
 *                                                  46%                I
1*--------------------------------------------------I                  I
 *                                                  I      39%         I
 *                                                  I------I           I
 *                                                  I      I           I
3*--------------------------------------------------I      I           I
 *                                                         I-----------I
 *                                                         I
 *                                                         I
4*---------------------------------------------------------I
```